7.6 Properties of the Equilibrium Constant

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS equilibrium constant

Objective

Build the skills to answer exam questions on the **properties of the equilibrium constant**.

You must be able to:

- **reverse** a reaction ($K \to 1/K$)
- **scale** a reaction by n ($K \to K^n$)
- **add** reactions ($K \to K_1 \times K_2$)

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later – follow the steps and you can do the Practice and Exam-style questions yourself.

■ Reversing a reaction

Reversing an equation **inverts** the constant:

$$K_{\text{reverse}} = \frac{1}{K_{\text{forward}}}.$$

■ Scaling a reaction

Multiplying all coefficients by n raises K to the power n:

$$K_{\text{new}} = (K_{\text{old}})^n.$$

■ Adding reactions

If you add two reactions, you **multiply** their constants:

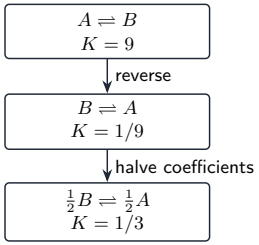
$$K_{\text{total}} = K_1 \times K_2.$$

■ A worked example

If $K = 4$ for a reaction, then the reverse has $K = \frac{1}{4}$; doubling the equation gives $K = 4^2 = 16$; halving gives $K = 4^{1/2} = 2$.

■ Worked application: Transform the equation before its equilibrium constant

For the hypothetical equilibrium $A \rightleftharpoons B$ at a fixed temperature, let $K = 9$. Reversing gives $B \rightleftharpoons A$ with $K = 1/9$. Halving that reversed equation gives $\frac{1}{2}B \rightleftharpoons \frac{1}{2}A$ with $K = (1/9)^{1/2} = 1/3$. It does not give $1/18$: coefficients become exponents in the equilibrium expression. If another reaction has $K = 4$ and is added so that species cancel correctly, the constant for the sum is the product of the transformed constants. All constants must refer to the same temperature.



2 Practice

Now apply the methods above.

2.1 A reaction has $K = 100$. Find K for the reverse reaction. [1]

2.2 A reaction has $K = 3$. Find K if all coefficients are doubled. [1]

2.3 Two reactions with $K_1 = 2$ and $K_2 = 5$ are added. Find K for the sum. [1]

3 Exam-style questions

3.1 Reversing a reaction changes K to [1]

- **A** $-K$
- **B** $1/K$
- **C** K^2
- **D** $2K$

3.2 A reaction has $K = 16$.

(a) Find K for the reaction written with all coefficients halved. [2]

(b) Find K for the reverse of the halved reaction. [2]

3.3 Given A $\rightleftharpoons$ B, $K_1 = 4$, and B $\rightleftharpoons$ C, $K_2 = 3$, find K for A $\rightleftharpoons$ C. [2]

3.4 At the same temperature, $A \rightleftharpoons B$ has $K = 16$ and $B \rightleftharpoons C$ has $K = 3$. Find K for $A \rightleftharpoons C$, then find K for $\frac{1}{2}C \rightleftharpoons \frac{1}{2}A$. Show the transformations. [4]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $\frac{1}{100} = 0.01$

2.2

- $3^2 = 9$

2.3

- $2 \times 5 = 10$

3.1 B

- $1/K$

3.2

(a)

- $16^{1/2} = 4$

(b)

- $\frac{1}{4} = 0.25$

3.3

- Adding the reactions multiplies the constants: $K = 4 \times 3 = 12$

3.4

Adding cancels B and multiplies constants, giving $K = 16 \times 3 = 48$. Reverse and halve the sum: $K = (1/48)^{1/2}$, approximately 0.144.